## REMARKS

Claims 19-28, 30, 31, 33, 34, 37 and 39-42 are pending in this application. Claims 19, 31 and 40 have been amended. Claims 35 and 36 have been canceled and their subject matter has been incorporated in amended independent claim 31. New claim 42 has been added to round out the scope of protection afforded by the present invention. No new matter has been introduced.

Claims 19, 21, 22, 24, 25, 28 and 30 stand rejected under 35 U.S.C. §102(e) as being anticipated by Anand (U.S. Patent No. 6,362,528) ("Anand"). This rejection is respectfully traversed.

The claimed invention relates to a dual damascene structure comprising a titanium-silicon-nitride layer. As such, amended independent claim 19 recites a "dual damascene structure" comprising *inter alia* a metal layer provided within a first insulating layer, "a second insulating layer provided over said metal layer" and "a via situated within said second insulating layer and extending to at least a portion of said metal layer, said via being lined with an organo-metallic-atomic deposited titanium-silicon-nitride layer having a step coverage of about 100% and filled with a copper material." Amended independent claim 19 also recites a trench situated within a third insulating layer and "lined with said organo-metallic-atomic deposited titanium-silicon-nitride layer and filled with said copper material."

Anand relates to a "bonding pad . . . formed in a lattice-like shape." (Abstract). According to Anand, the bonding pad is "constituted by a conductive member filled in grooves made in an insulating layer having a flat surface." (Col. 7, lines 26-28). Anand also teaches "an etching stopper layer formed on the insulating layer and having an opening to expose the bonding pad" and "a passivation layer formed on the etching stopper layer and having an opening to expose the bonding pad." (Col. 7, lines 28-33).

Anand does not disclose all the limitations of claims 19, 21, 22, 24, 25, 28 and 30. Anand does not teach or disclose a "dual damascene structure" comprising *inter alia*

"a via situated within said second insulating layer . . . said via being lined with an *organo-metallic-atomic deposited titanium-silicon-nitride layer* . . . and filled with a copper material," as amended independent claim 19 recites (emphasis added). According to Anand, barrier metal 17a, which would arguably correspond to the organo-metallic-atomic deposited titanium-silicon-nitride layer, is formed "on the insulating layer 25, on an inner surface of the contact hole 16a and the inner surfaces of the grooves 16b *by the CVD method or PVD method*" and "is made of, for examples a lamination of titanium and titanium nitride, or silicon titanium nitride." (Col. 12, lines 7-12; Fig. 31) (emphasis added).

Anand is also silent about "a via . . . being lined with an organo-metallic-atomic deposited titanium-silicon-nitride layer *having a step coverage of about 100%* ," as amended independent claim 19 recites (emphasis added). The crux of Anand is preventing dishing which occurs as a result of excessive etching of the bonding pad during CMP processing, and not achieving a good step coverage in damascene processing, as in the claimed invention. Anand specifically mentions that "[s]uch dishing easily causes a bonding error, that is, a wire cannot be bonded to the bonding pad . . . accurately during a wiring bonding operation, which results in the deterioration of the production yield." (Col. 3, lines 18-22). Thus, Anand fails to anticipate all limitations of amended independent claim 19, and withdrawal of the rejection of claims 19, 21, 22, 24, 25, 28 and 30 is respectfully requested.

Applicants also reaffirm that the limitation "organo-metallic-atomic deposited titanium-silicon-nitride layer" is not a product-by-process limitation, as the last Office Action asserts, but rather is a *resulting structure* having defined and distinct characteristics. Applicants maintain all remarks and arguments with respect to the limitation "organo-metallic-atomic deposited titanium-silicon-nitride layer" as a resulting structure, as set forth in detail in previous responses to office actions, including the August 21, 2003 Amendment After Final Action. Applicants note that a titanium-silicon-nitride layer formed by an organo-metallic-atomic deposition technique has structural characteristics different from those of a titanium-silicon-nitride layer formed by a chemical vapor deposition (CVD)

technique, including metal organic chemical vapor deposition (MOCVD). Applicants point out to Min et al., *Metal-organic atomic-layer deposition of titanium-silicon-nitride films*, Appl. Phys. Lettrs., Vol. 75, No. 11, pp. 1521-23 (1999) ("Min"), which specifically compares a ternary (Ti-Si-N) film formed by a MOALD process and by a MOCVD process. In comparing the two methods of Ti-Si-N film formation, Min analyzes the "dependence of Si content on the $SiH_4$ partial pressure" of Ti-Si-N films in both the MOALD and MOCVD methods and concludes that "[t]he MOALD process has a great potential for excellent step coverage due to the complete surface reaction" and that it "demonstrates the perfect step coverage of MOALD." Accordingly, an "organo-metallic-atomic deposited titanium-silicon-nitride layer" is not a product-by-process limitation, but rather a *resulting structure* having defined characteristics and distinct from those of Ti-Si-N films formed by other known methods, such as the CVD method.

Claims 19, 21, 22, 24, 25, 28 and 30 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Anand in view of Min et al. in *Metal-organic atomic-layer deposition of titanium-silicon-nitride films*, Appl. Phys. Lettrs., Vol. 75, No. 11, pp. 1521-23 (1999) ("Min"). This rejection is respectfully traversed.

Min relates to achieving "near-perfect step coverage" and "control[ling] precisely the thickness and composition of grown films" by metal-organic atomic-layer deposition. As emphasized by Min et al., "the MOALD (metal-organic atomic-layer deposition) process has great potential for excellent step coverage on severe surface topography due to the complete surface reaction" particularly for Ti-Si-N films with less than 10nm thickness. Id. at 1523.

The subject matter of claims 19, 21, 22, 24, 25, 28 and 30 would not have been obvious over Anand in view of Min. Indeed, the Office Action fails to establish a *prima facie* case of obviousness. To establish a *prima facie* case of obviousness, three requirements must be met: (1) some suggestion or motivation, either in the references themselves or in the knowledge of a person of ordinary skill in the art, to modify the reference or combine reference teachings; (2) a reasonable expectation of success; and (3)

the prior art reference (or references when combined) must teach or suggest all the claim limitations. M.P.E.P. § 2142. See, e.g., In re Royka, 490 F.2d 981, 180 U.S.P.Q. 580 (CCPA 1974).

In the present case, neither Anand nor Min, whether considered alone or in combination, teaches or suggests the limitations of claims 19, 21, 22, 24, 25, 28 and 30. As discussed above, Anand fails to teach or suggest "dual damascene structure" comprising *inter alia* "a via situated within said second insulating layer . . . said via being lined with an organo-metallic-atomic deposited titanium-silicon-nitride layer having a step coverage of about 100% and filled with a copper material," as amended independent claim 19 recites. Min is silent about a dual damascene structure, much less about a "dual damascene structure" having a metal layer provided within a first insulating layer, "a second insulating layer provided over said metal layer" and "a via situated within said second insulating layer and extending to at least a portion of said metal layer, said via being lined with an organo-metallic-atomic deposited titanium-silicon-nitride layer having a step coverage of about 100% and filled with a copper material," as amended independent claim 19 recites.

In addition, a person of a person of ordinary skill in the art would not have been motivated to combine the teachings of Anand with those of Min, as the Office Action asserts. On one hand, the crux of Anand is the formation of a bonding pad formed in a lattice-like shape in which dishing is minimized. Anand specifically mentions that "[s]uch dishing easily causes a bonding error, that is, a wire cannot be bonded to the bonding pad . . . accurately during a wiring bonding operation, which results in the deterioration of the production yield." (Col. 3, lines 18-22). On the other hand, the crux of Min is the metal-organic atomic-layer deposition of titanium-silicon-nitride films. For this, Min specifically analyzes the "dependence of Si content on the $SiH_4$ partial pressure" of Ti-Si-N films in both the MOALD and MOCVD methods and concludes that "[t]he MOALD process has a great potential for excellent step coverage due to the complete surface reaction" and that it "demonstrates the perfect step coverage of MOALD." Thus, it is clear that the only element which Anand and Min have in common is the substrate on which their respective structures are formed. Accordingly, a person of ordinary skill in the art would not have

been motivated to combine Anand with Min, and withdrawal of the rejection of claims 19, 21, 22, 24, 25, 28 and 30 is also respectfully requested.

Claims 20, 23, 31, 33, 34, 37 and 39 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Anand and Min in view of Venkatraman et al. (U.S. Patent No. 6,093,966) ("Venkatraman"). This rejection is respectfully traversed.

Amended independent claim 31 recites "a damascene structure" comprising *inter alia* a metal layer "provided within" a first insulating layer, "at least another insulating layer provided over said metal layer, said at least another insulating layer including a material selected from the group consisting of polyimide, spin-on-polymers, flare, polyarylethers, parylene, polytetrafluoroethylene, benzocyclobutene, SILK, fluorinated silicon oxide, hydrogen silsesquioxane and NANOGLASS." Amended independent claim 31 also recites "at least one opening situated within said at least another insulating layer . . . being lined with a titanium-silicon-nitride layer having a thickness of about 100 Angstroms and filled with a copper material."

Amended independent claim 40 recites "a damascene structure" which is part of a processor-based system and which comprises *inter alia* "a metal layer provided within a first insulating layer" and "at least another insulating layer provided over said metal layer, said first insulating layer and said at least another insulating layer including a material selected from the group consisting of polyimide, spin-on-polymers, flare, polyarylethers, parylene, polytetrafluoroethylene, benzocyclobutene, SILK, fluorinated silicon oxide, hydrogen silsequioxane and NANOGLASS." Amended independent claim 40 also recites "an etch stop layer provided between said first insulating layer and said at least another insulating layer" and "at least one opening situated within said at least another insulating layer and . . . lined with an organo-metallic-atomic deposited titanium-silicon-nitride layer and filled with copper."

Venkatraman relates to "a semiconductor device having a copper barrier layer." (Col. 1, lines 7-8). Venkatraman recites a copper barrier layer formed when the substrate is "biased by a first stage bias followed by a second stage bias to accelerate the plasma to the

substrate . . . where the first stage bias is less than the second stage bias." According to Venkatraman, the "copper barrier layer 200 is typically a tantalum silicon nitride layer, but may be composed of any combination of refractory metal . . . together with silicon and nitrogen" and "is deposited on the second oxide layer 190 and the insulating layer 180 and along the sidewalls of the opening 195 and 196." (Col. 5, lines 20-26; Fig. 7).

The subject matter of claims 20, 23, 31, 33, 34, 37 and 39 would not have been obvious over Anand and Min in view of Venkatraman. Again, the Office Action fails to establish a *prima facie* case of obviousness. In the present case, none of Anand, Min and Venkatraman, whether considered alone or in combination, teaches or suggests the limitations of claims 20, 23, 31, 33, 34, 37 and 39. As discussed above, Anand and Min fail to teach or suggest "dual damascene structure" comprising *inter alia* "a via situated within said second insulating layer . . . said via being lined with an organo-metallic-atomic deposited titanium-silicon-nitride layer having a step coverage of about 100% and filled with a copper material," as amended independent claim 19 recites. Venkatraman discloses a copper barrier layer that is "typically a tantalum silicon nitride layer, but may also be composed of any combination of refractory metal such as molybdenum, tungsten, titanium, vanadium together with silicon and nitrogen." (Col. 5, lines 22-26). Venkatraman, however, fails to teach or suggest "an organo-metallic-atomic deposited titanium-silicon-nitride layer having a step coverage of about 100%," as amended independent claim 19 recites.

Anand and Min also do not teach or suggest an "insulating layer including a material selected from the group consisting of polyimide, spin-on-polymers, flare, polyarylethers, parylene, polytetrafluoroethylene, benzocyclobutene, SILK, fluorinated silicon oxide, hydrogen silsesquioxane and NANOGLASS" and "at least one opening situated within said at least another insulating layer . . . being lined with a titanium-silicon-nitride layer having a thickness of about 100 Angstroms and filled with a copper material," as amended independent claim 31 recites. Venkatraman also fails to teach or suggest the limitations of amended independent claim 31. Venkatraman teaches an insulating layer including "organic thermoplastic and thermosetting polymers such as polyimides,

polyarylethers, benzocyclobutenes, polyphenylquinoxalines, polyquinolines . . . and polymers of polysiloxane" (Col. 4, lines 42-53).

Anand, Min and Venkatraman, whether considered alone or in combination, also fail to teach or disclose an "insulating layer including a material selected from the group consisting of polyimide, spin-on-polymers, flare, polyarylethers, parylene, polytetrafluoroethylene, benzocyclobutene, SILK, fluorinated silicon oxide, hydrogen silsesquioxane and NANOGLASS" and "an etch stop layer provided between said first insulating layer and said at least another insulating layer," as amended independent claim 40 recites. Anand teaches that "an insulating film (borophospho silicate glass (BPSG) or the like) 15 . . . is formed on the transistor" (col. 11, lines 36-39; fig. 27) and that "insulating layer 25 is made of, for example, silicon oxide" (col. 11, line 44; Fig. 28), and not of the materials recited in amended independent claim 40. For at least these reasons, Anand, Min and Venkatraman do not disclose all limitations of claims 19, 21, 22, 24, 25, 28, 30, 40 and 41, and withdrawal of the rejection of these claims is respectfully requested.

Claims 26 and 27 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Anand and Min and further in view of *Ti-Si-N Diffusion Barriers Between Silicon and Copper* by J.S. Reid et al. ("Reid"). This rejection is respectfully traversed.

Claims 26 and 27 depend from amended independent claim 19. As discussed above, Anand fails to teach or suggest a "via being lined with an *organo-metallic-atomic deposited titanium-silicon-nitride layer having a step coverage of about 100%* and filled with a copper material," as amended independent claim 19 recites (emphasis added). Reid teaches that "$Ti_{34}Si_{23}N_{43}$ thin films are exceptional diffusion barriers between silicon and copper" and that "100 nm and 10 nm films are able to prevent copper from reaching the silicon" (page 299, second column, last paragraph), but Ti-Si-N thin film "depositions were made by rf-sputtering in a chamber." (Page 298, first column, second paragraph). As discussed above, it is known that deposition by ALD provides improved step coverage over deposition by sputtering, which is particularly important for the Ti-Si-N diffusion barrier deposited on the sidewalls of vias and trenches. Therefore, the product of "organo-

metallic-atomic deposited titanium-silicon-nitride layer" is not taught or suggested by Anand, Min or Reid. Since Anand, Min and Reid do not teach or suggest all the limitations of amended independent claim 19, the subject matter of claims 26 and 27 would not have been obvious over Anand and Min in view of Reid, and withdrawal of the rejection of these claims is respectfully requested.

New independent claim 42 has been added to round out the scope of protection afforded by the present invention. Newly added independent claim 42 recites a "damascene structure" comprising *inter alia* "a first insulating layer," "a metal layer provided within said first insulating layer" and "at least another insulating layer provided over said metal layer, said at least another insulating layer including a material selected from the group consisting of polyimide, spin-on-polymers, flare, polyarylethers, parylene, polytetrafluoroethylene, benzocyclobutene, SILK, fluorinated silicon oxide, hydrogen silsesquioxane and NANOGLASS." Newly added independent claim 42 also recites "an etch stop layer provided over and in contact with said at least another insulating layer" and "at least one opening situated within said at least another insulating layer and said etch stop layer, and extending to at least a portion of said metal layer, said opening being lined with a titanium-silicon-nitride layer and filled with a copper material." Applicants submit that none of the cited prior art references, considered alone or in combination, teaches or suggests all limitations of newly added independent claim 42.

In view of the above, each of the presently pending claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to pass this application to issue.

Dated: December 10, 2003

Respectfully submitted,

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